

**Energy Management Programs at the John. F. Kennedy  
Space Center**

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# Energy Management Projects at the John. F. Kennedy Space Center

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## Abstract

The Energy Management internship over the summer of 2011 involved a series of projects related to energy management on the John. F. Kennedy Space Center (KSC). This internship saved KSC \$14.3 million through budgetary projections, saved KSC \$400,000 through implementation of the recycling program, updated KSC Environmental Management System's (EMS) water and energy-related List of Requirements (LoR) which changed 25.7% of the list, provided a incorporated a 45% design review of the Ordnance Operations Facility (OOF) which noted six errors within the design plans, created a certification system and timeline for implementation regarding compliance to the federal Guiding Principles, and gave off-shore wind as the preferred alternative to on-site renewable energy generation.

## I. Introduction

The John F. Kennedy Space Center (KSC) near Merritt Island in Florida has many options through which it can cut both energy consumption and costs. The approximately 219 square miles of wildlife refuge is littered with facilities which date back to 1962, the year of KSC's inception. These facilities have seen some renovations and additions, but are long due for major updates. The internship program for the summer of 2011 was coincidental with the end of the space shuttle program. This coincidence provided additional life-cycle cost effective projects to assist with in the internship program.

A number of matters related to KSC's energy and sustainability were tackled within the 10 week period. Over this time, the internship aided in the implementation of the Shuttle T&R (Transition and Retirement) Recycling program, brought about a \$14.3 million decrease in KSC Transition Management's FY 12 Budget Projections, and updated a list of KSC-applicable water and energy federal requirements for the Environmental Management System. The internship further incorporated a 45% design review of the Ordnance Operations Facility Construction of Facilities (CoF) Project, in-depth research regarding the applicability of the Federal Leadership in High Performance and Sustainable Buildings' (FLHPSB) Guiding Principles, research into renewable energy generation on KSC, and shadowing opportunities with various engineers.

## II. Background

The different projects are all based around conservation and sustainability. However, each project has its own purpose and reasoning for implementation. This section examines these purposes, explaining the intent of the different programs.

### A. Shuttle Transition and Retirement Recycling Program

Along with the retirement of the National Aeronautics and Space Administration's (NASA) 30-year shuttle program, three decades worth of paperwork need to be recycled. Prior to the shuttle transition and retirement recycling program, KSC sent all recycled documents to a contractor for processing. Documents that were Sensitive But Unclassified (SBU) needed shredding, so KSC was charged an additional fee of nine cents per pound for all SBU documents.

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The Shuttle T&R Recycling Program is a revolutionary idea meant to replace this program, cutting costs by approximately \$400,000. The main difference between the Shuttle T&R Recycling Program and the original program is that paper is returned to KSC after processing. In the Shuttle T&R Recycling Program, both SBU and non-SBU documents go through a process of “de-inking.” This process removes the ink from the sheets of paper and produces a post-manufacturing material that can be used in remanufacturing. The ownership of this paper remains in the hands of KSC and is sold off to a remanufacturing plant where it is processed into recycled paper. The proceeds from this process go directly to KSC’s recycle funds.

The program’s second impact is that it gives jobs to disabled citizens. The recycling program that is contracted for the de-inking process hires the disabled. In this sense, the program gives jobs to the disabled.

A related project to this is the recycling of office supplies of employees of the United Space Alliance (USA). As facilities formerly occupied by USA become vacant, a lot of leftover, unused office supplies are being tossed out. This project donates those office supplies to schools within Florida’s counties. The vast amount of pens, pencils, binders, paper clips, and other office supplies are shipped off to the different schools for use in classrooms, preventing further additions to the waste stream while helping out the development of our next generation.

#### **B. Kennedy Space Center – Transition Management (KSC-TM) FY 12 Budget Projections**

With the retirement of the shuttle program and site-wide budget cuts resulting from it, proper budgeting for FY 12 for all KSC facilities is absolutely critical. Specifically, budget projections for all facility energy budgets need to reevaluate the energy costs of buildings which support the shuttle program. After all, some of these buildings will no longer be used. Some buildings will be put on the demolition list; others will be put on the “mothballed” list. A mothballed building is kept in a low energy state so that it can be quickly reactivated for use should the need arise.

#### **C. Environmental Management System (EMS) List of Requirements (LoR) Update**

As per NASA Procedural Requirement (NPR) 8553.1<sup>1</sup>, KSC is required to keep a list of applicable List of Requirements (LOR) for all environment related federal requirements. The compilation of this list of requirements makes it easier for each center to acknowledge and comply with the requirements which are listed within the LoRs. The LoR also makes it easier for each center to keep track of what is relevant to the respective center and to establish goals in order to surpass compliance. These environmentally related federal requirements encompass a large range of requirements, including Air Emissions, Energy, Hazardous Materials, Fleet Efficiencies, etc. Updates on these requirements need to be made on an annual basis.

#### **D. 45% Design Review of the Ordnance Operations Facility (OOF) Construction Project**

In order to ensure that a design for a construction project is to meet its requirements, a design review needs to be performed partway into the design process. The review accomplishes multiples purposes. Firstly, it makes sure that the intent of the design is communicated throughout the design group. Secondly, it makes sure that designed features of the various disciplines do not conflict with each other. It seeks to correct errors made in the building design in order to reduce errors during building construction. The theory is that the longer a design error goes unnoticed, the harder it is to correct for. Finally, the design review makes sure that the design meets the main objectives of the project. Doing this review ensures the designer does not cut corners in meeting the project manager’s design objectives.

When performing a design review, the design plans, statement of work, and other design related materials and plans are inspected. The design plans themselves are broken up into a series of disciplines. These disciplines include architecture, electricity, environment, mechanics, and fire protection, just to name a few. The different disciplines analyze the building with regard to that specific aspect. The sheets of the design plan relating to the mechanical discipline, for example, would address the HVAC system of the building.

At the time of the internship, the OOF Construction Project had already been completed. As a result, a design review of the OOF was performed in order to gain a better understanding of the design review process. This facility was chosen because it was the facility that was most recently built, allowing for site visits to see implemented changes.

#### **E. Guiding Principles and Leadership in Energy and Environmental Design (LEED)**

In accordance with Executive Order (E.O.) 13423<sup>2</sup> and E.O. 13514<sup>3</sup>, 15% of all facilities of any federal agency must be in compliance with the “Guiding Principles” as modified by the Interagency Sustainability Working Group (ISWG) by 2015. The Guiding Principles was initially defined in the FLHPSB’s 2006 Memorandum of Understanding (MoU). This MoU was drafted with the idea that the federal government should lead the country in

implementing sustainability measures. As such, the Guiding Principles were created to characterize the sustainable building according to the drafters' vision.

Unfortunately, the drafters were not very specific with their goals and so further interpretation was needed. As a result, the ISWG was formed in the initial MoU and was given authority over the Guiding Principles' interpretation. In 2008, the ISWG produced a second set of Guiding Principles, applying to buildings already in existence. Furthermore, they put out a set of responses in reply to a number of questions that were asked by federal agencies regarding the Guiding Principles.

This internship dealt with implementing a more quantifiable explanation of some of the details within the Guiding Principles. Despite the work that ISWG has done to explain the vision set forth, there are still many details within the Guiding Principles that require further interpretation. To avoid this, KSC came to the conclusion that LEED certification was equivalent to meeting the Guiding Principles. Later research done through this internship proved this substitution to be not sufficient to meeting the Guiding Principles.

To provide a background of the confusion, LEED was created by the United States Green Building Council (USGBC) as a certification system for sustainable buildings. LEED certification for building construction means that the building is both designed and constructed in a sustainable manner. LEED certification for operations and maintenance means that the building is planned to be and continues to be maintained in a sustainable manner. For both types, there are sliding scales of certification, ranging from base certification, where the minimum requirements are met, to "Platinum" certification, where the building far exceeds the council's standards in sustainability. The determination of different LEED certifications is based off of a credit system. If a project meets a certain requirement, it achieves a certain number of points for that requirement. Certain thresholds of points determine a respective certification level. And because LEED is such a well acknowledged certification system, it has spread to KSC and has been in the works for implementation.

#### **F. Renewable Energy Generation Research**

This research focuses on problems regarding implementation of wind energy at KSC. According to E.O. 13514, agencies shall aim to implement renewable power generation on site and shall have 5% of net energy usage come from renewable sources. On-site renewable sources produce twice the energy credits when reviewing this criteria.

So in order to help KSC realize this goal, different sources of renewable power are looked into. Solar, a good choice for areas in the state of Florida, has already seen the initial demonstration project with Florida Power and Light's (FPL) construction of two solar farms on site. However, wind has received little support. In the past, FPL proposals to start a wind project on KSC property were halted by the US Fish and Wildlife, citing avian mortality and lack of sufficient wind resource to be cost effective. This internship aims to recognize and assess these problems while giving recommendations for future wind generation proposals.

### **III. Implementation and Methodology**

This section describes the methods for implementation, calculation, update, review, drafting, and research for the different projects that were involved in this internship.

#### **A. Shuttle T&R Recycling Program**

In implementing the Shuttle T&R Recycling Program, many site visits were made. During these site visits, recycle bins were put into buildings which will be emptying the most paper, specifically those with many employees who are related to the shuttle program. These recycle bins are taken out every Monday, Tuesday, and Thursday. In addition, the recycling company sends a worker out to pick up the bins when an employee calls in.

The office supply recycling program also required site visits to the Operations Support Bay (OSB) I, OSB II, and the Processing Control Center (PCC). During these site visits, supplies are boxed up, loaded into vans, and moved into the old Propellants North building, just outside the new Propellants North building.

#### **B. KSC-TM FY 12 Budget Projections**

The KSC-TM FY 12 Budget is prepared using data from the Automated Utility Database Reporting & Information System (AUDRIS), KSC's database of meter readings. Specifically, the FY 08, FY 09, and FY 10 data is used in conjunction with FY 11 data to predict the data for the months remaining in FY 11. The energy usage change between the average of the annual energy usage of FY 08, FY 09, and FY 10 and the average of the predicted FY 11 energy usage is predicted to stay the same between FY 11 and FY 12. Using this prediction, one can then predict the FY 12 energy usage.

Once the energy usage is predicted for FY 12, the FY 10 cost of energy is then used to predict FY 12 energy costs. Calculating for inflation for the two years, the FY 12 per unit energy cost is assumed to be the same as the FY 10 per unit energy cost, both of which are in FY 10 dollars. Translating FY 12's per unit energy cost to FY 12 dollars gives an estimation of the FY 12 energy budget. This information is processed for all buildings with initially predicted FY 12 budgets greater than \$25,000. Additional calculations reveal that the predictions for these buildings sum up to 95% of the estimated budget.

### **C. EMS LoR Update**

Updating the LoR requires a thorough review of federal requirements, state requirements, and NASA requirements. In order to update both these requirements, it is important to look at the source of the requirements. For federal requirements, the sources are the Code of Federal Regulations (CFR), the United States Code (USC), and the list of E.O.'s. These can all be found online, in the Federal Register. The CFR and the USC both have sections that are specific to a topic, making it easier to search for related topics. However, the E.O.s do not have these sections. Therefore, going through all of the E.O.s is necessary. For state requirements, the source is the Florida Statutes. For NASA requirements, the sources are the Kennedy NASA Procedural Requirements (KNPR), the Kennedy NASA Policy Directives (KNPD), the NASA Procedural Requirements (NPR), and the NASA Policy Directives (NPD).

The updating process took no heed of the previous listing of all the applicable requirements that related to water and energy. Instead, the process required looking through the different sources of requirements to find for water and energy related requirements. Once a list is compiled, the list is then compared against the previous list to check for differences. Those differences are examined by looking into the full text of the requirement, specifically looking for its relation to water and energy on KSC. Those that apply are filed on the LoRs. Those that are not are removed from the list.

### **D. 45% Design Review of the OOF Construction Project**

Performing a design review requires an understanding of design principles and the construction process. In looking through the design plans for errors in design, it is necessary first to look at the statement of work in order to get an understanding of the original design goals of the project. Once that is thoroughly understood, the design goals are taken into consideration while the design plans are examined. The design plans are looked through to make sure that the design meets the original design goals.

Comments are also made when something is amiss, such as missing intakes vent of the HVAC system or overlapping sensors and speakers. In addition to these types of errors, communication errors are also noted. These are errors in which the designer's intent is not obvious. Noting these problems will prevent confusion in the construction process.

### **E. Guiding Principles and LEED**

In order to better define the Guiding Principles, it is necessary to break them up into its constituent parts. From there, each individual line item needs to be correlated to a LEED credit. The LEED credits also need to be summarized in order to quickly compare similar credits. When LEED credits are summarized and the Guiding Principles are broken up for both New Construction (NC) and Existing Buildings (EB), the credits are cross examined. When two existing credits are present, the credit that is stricter is kept. The other one is put aside. Doing this for every Guiding Principle credit creates a new set of "Guiding Principles" which is more strict and detailed than the Guiding Principles produced by the ISWG.

After these set of credits are drafted, the credits are each given a point value, as in LEED. This point system is used in conjunction with another drafted incentive system for the Architect/Engineer (A/E). That is, in order to encourage design implementation of items listed in the Guiding Principles and LEED combined certification system, the A/E of the project will be rewarded for meeting a specific certification level. Like LEED, this certification level is determined by the number of points met, allowing the A/E freedom for choosing the most cost-effective and applicable items. Despite the freedom allowed to the A/E, this creates a consistent standard regardless of the intent of the project.

### **F. Renewable Energy Generation Research**

Because the research's intent is to look into the prospect of electric uses of wind energy and provide recommendations, the research requires looking into a few specific areas. Looking into wind resource is of concern to any wind project. This helps to determine life cycle cost effectiveness of the project and also to determine the

limits of generated wind energy. For on and off-shore wind resources, this is available on the National Renewable Energy Laboratory (NREL) website.

In addition to this, however, is avian mortality. Looking at avian mortality with regard to wind turbines is very important because KSC is on a wildlife refuge and because a wind project had been rejected for this reason. While disproving avian mortality in regard to wind turbines could suffice, a better option is to propose an alternative which avoids this problem. This is the approach taken in this research.

#### **IV. Results and Records**

This section details the results of the program, the projection, the update, the review, the compilation, and the research where appropriate.

##### **A. Shuttle T&R Recycling Program**

The Shuttle T&R Recycling Program transpired with only a few hiccoughs. The problems are all related, however, to the sheer amount of paper that was tossed out. The recycling company's regular schedule was not sufficient to keep the bins empty. In addition, problems with the workers' schedules with the recycling company prevented a few extra bins from getting emptied. Finally, employees would move recycle bins around, preventing the workers from the recycle company from getting to the bins in an efficient manner.

The office supplies recycling project, however, had a much larger problem. Despite six hours of work each, eight people were only able to move out three cubicles' worth of office supplies. These cubicles of office supplies comprised approximately 2% of the project's total office supplies. This provided an indicator that the project required a lot more time than expected.

##### **B. KSC-TM FY 12 Budget Projections**

The KSC-TM FY 12 Budget Projections were not utilized by the CoF. However, when presented to them, the CoF recognized that there were egregious errors on their initially prepared budget. This led to a meeting in which the CoF pondered on a good method of budgetary projection procedures. During this meeting, it was discovered that such a procedure already existed. When putting the numbers through this procedure, the new CoF submission for the FY 12 budget was projected at \$14.3 million less than the original projection, a 38.5% difference.

This submission provided through this internship was more aggressive than the final one presented by the CoF; rather than a 38.5% difference from the CoF budget, this internship's submission projected a 40% difference from the initial numbers. While the budget projections were not utilized by the CoF, the projection still led to a general awareness of the methods for budgetary projections for the future and brought about a \$14.3 million savings.

##### **C. EMS LoR Update**

The details in the final set of LoR were more specific and less vague where possible. After painstakingly going through each individual section of the CFR, the USC, the E.O.s, the KNPR, the KNPD, the NPR, and the NPD, requirements that were noted as containing multiple requirements were expanded to note which specific requirements were applicable to KSC. Those requirements that were not noted at all were added.

As a result of this update, one requirement was made more specific, creating two requirements, eight old requirements were removed, and eight new requirements were added. With a total of 35 requirements listed in the pre-updated LoR, the percentage of requirements that were newly added is 25.7%. With a total of 35 requirements listed in the post-updated LoR, the percentage of requirements that were changed is 28.6%. The most recent EMS LoR is listed in Appendix I.

##### **D. 45% Design Review of the OOF Construction Project**

The 45% design review revealed six errors in the design plans. One of these errors was a calculation error, regarding net square footage. The remaining errors were related to failure in detailing specific references. In one case, there was a missing cross section of a HVAC system. In four others, notes referenced details that did not exist. These errors were noted for future reference.

##### **E. Guiding Principles and LEED**

While a compiled list was not created, the LEED NC, LEED EB, Guiding Principles NC, and Guiding Principles EB were broken down into its constituents. Because LEED EB focused more with making plans for changes rather than detailing what is involved with actual changes, LEED NC is used as a cross referencing source.

The relation of both versions of the Guiding Principles were both correlated to its respective LEED NC credit. However, these were simply not compiled into a complete list for certification.

The timeline, however, was drafted for implementation. The timeline can be found in Appendix II.

#### F. Renewable Energy Generation Research

The overall conclusion from the Renewable Energy Generation is that off-shore electric wind generation is the preferable technology to look into when taking a look at wind turbine implementation. For one, the wind resource off-shore is better, providing on average of 50% more energy than on-shore resources would. Secondly, the avian mortality situation is greatly reduced, because the turbines would be placed off the coast of the Merritt Island Wildlife Refuge rather than on it. However, looking towards the future, two considerations to keep in mind are the land boundary issues related to off-shore lands and the effects of wind turbines on sea-life. The summary documenting this research can be found in Appendix III.

#### V. Conclusion

This internship provided a series of topics to both make a difference with and to learn from. The Shuttle T&R Recycling Project provided a chance to do some site visits and to become familiar with the KSC site. The KSC-TM FY 12 Budget Projections brought about a \$14.3 million reduction in the estimated budget while, providing a more in-depth understanding of how the budgeting process works in federal agencies. The update of the EMS LoR produced a more succinct LoR, while giving insight into the structure of federal, state, and local requirements for federal agencies. The 45% Design Review offered a pre-emptive review of the OOF project design while giving a glance at the construction and design processes, showing what is important to construction and design and what is not. The Guiding Principles compilation produced a certification process and a timeline for implementation, simultaneously revealing how complex change is within a federal agency and revealing the steps necessary to effect a change. Finally, the renewable energy generation research gave KSC technological feasibility review for future electric wind energy projects and concurrently presented the viewpoint of the implementer of such a technology rather than that of a researcher. For a student who is has declared a minor in energy, this presenting of a implementation viewpoint provides a more worldly understanding of the energy crisis.

#### Appendix

##### Appendix I: EMS LoR Update

Executive Orders		Florida Statutes		NPR/NPD	
<u>EO 11912</u>	Buildings and Facilities - Energy Conservation	<u>TITLE XXVII</u>	<u>Renewable Energy, Ch 366.91</u>	<u>NPR 8530.1</u>	Affirmative Procurement Program and Plan for Environmentally Preferable Products
<u>EO 13211</u>	Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use	<u>TITLE XXVII</u>	<u>Florida renewable energy policy, Ch 366.92</u>	<u>NPR 8553.1</u>	NASA EMS
<u>EO 13212</u>	Actions To Expedite Energy-Related Projects	<u>TITLE XXIX</u>	<u>Environmental Control, Chapter 403</u>	<u>NPR 8570.1</u>	Energy Efficiency and Water Conservation Technologies and Practices
<u>EO 13221</u>	Energy Efficient Standby Power Devices			<u>NPD 8820.2</u>	Design and Construction of Facilities
<u>EO 13302</u>	Amending EO 13212, Actions to Expedite Energy-Related Projects			<b>KNPR/KNPD</b>	
<u>EO 13337</u>	Issuance of Permits With Respect to Certain Energy-Related Facilities and Land Transportation Crossings on the International Boundaries of the United States			<u>KNPD 8500.1</u>	KSC Environmental Management
<u>EO 13423</u>	Strengthening Federal Environmental, Energy, and Transportation Management			<u>KNPR 8500.1</u>	KSC Environmental Requirements

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<u>EO 13514</u>	Federal Leadership in Environmental, Energy, and Economic Performance,		<u>KSC-PLN-1906</u>	KSC Energy Management Five-Year Plan
<u>CFR</u>			<u>CD COMM 2005-08</u>	Energy Conservation at KSC
<u>2 CFR 901</u>	Federal Agency Regulations for Grants and Agreements -Energy			
<u>10 CFR 300</u>	Voluntary Greenhouse Gas Reporting Program: General Guidelines			
<u>10 CFR 433</u>	Energy Efficiency Standards For The Design And Construction Of New Federal Commercial and Multi-Family High-Rise Residential Buildings			
<u>10 CFR 434</u>	Energy Code For New Federal Commercial And Multi-Family High Rise Residential Buildings			
<u>10 CFR 435</u>	Energy Efficiency Standards For New Federal Low-Rise Residential Buildings			
<u>10 CFR 436</u>	Federal Energy Management and Planning Programs			
<u>10 CFR 490</u>	Alternative Fuel Transportation Program			
<u>14 CFR 1216</u>	Aeronautics and Space: Environmental Quality			
<u>48 CFR 1801-1872</u>	FARS: NASA (NPR 5100.4B)			
<u>48 CFR 1-99</u>	FARS: FAR			
<u>48 CFR 23</u>	FARS: Environment, Energy and Water Efficiency, Renewable Energy Tech...			
<u>USC/Public Laws</u>				
<u>42 U.S.C. 6831-6892</u>	Energy Conservation Standards for New Buildings (Energy Conservation and Resource Renewal)			
<u>42 U.S.C. 8251, et seq</u>	National Energy Conservation Policy Act (NECPA) as amended			
<u>Public Law 100-12</u>	National Appliance Energy Conservation Act			
<u>Public Law 109-58</u>	Energy Policy Act of 2005			
<u>Public Law 110-140</u>	Energy Independence and Security Act of 2007			

## Appendix II: Guiding Principles and LEED

### Timeline

Currently:

LEED NC implementation

1 Year Goal:

Agree on a NC certification system that includes both LEED NC and GP NC

LEED EB implementation

2-3 Year Goal:

Implementation of the NC certification system



- Agree on an EB certification system that includes both LEED EB and GP EB
- 4 Year Goal:
  - Implementation of the incentive system for NC certification system
- 4-5 Year Goal:
  - Implementation of the EB certification system
- 6 Year Goal:
  - Implementation of the incentive system for EB certification system

### **Appendix III: Renewable Energy Generation Research**

#### **Initial Investigations of Wind Power at KSC**

Jeffrey H. Huang

##### **I. Introduction**

With federal renewable measures promoting renewable electrical power generation and consumption such as E.O 13514, 13423, EISA 2007, and the Guiding Principles popping up within the last half decade, on-site renewable resource generation is becoming more and more a viable option. This study looks into problems that wind generation on KSC faces. This study does not compare this resource to other possible types of renewable resources, nor does it perform a life-cycle cost analysis of implementing turbines. It does, however, address the categories of on-shore and off-shore wind generation and detail two specific factors that affect selection: wind resource and avian effects. Noise and aesthetics are not addressed in this study because these are of little concern on government lands.

##### **II. Data and Research**

Through a lengthy literature review, data regarding wind resources has been compiled below. This literature review encompasses two areas. The first area is related to wind resource. Without a proper wind resource, the turbine will not spin and will not produce energy. If this initial condition is not met, then wind energy would not be a preferable source of renewable generation. The second area of focus is the impact on birds and other avian wildlife.

###### *Wind Resource*

In order to determine what a "good" wind resource is, it is prudent to determine some of the design requirements of wind turbines. According to various online sources, the minimum wind speed required is between 7 and 10 mph. This wind speed minimum is based on the minimum speed that the wind needs to be at for the turbines to produce energy. The rated speed, that is the speed required to produce the power the turbine is rated for, is between 25 and 30 mph. That being said, average wind speeds rarely reach this high and tend to fluctuate between 15 and 20 mph. The cut-off speed is anywhere upward of 50 mph. This cut-off speed occurs at very high wind speeds, and happens so as to prevent damage to the turbine. These numbers give a range of what kind of wind speeds are preferred for renewable generation.

According to NREL wind resource data, the average wind speeds at an altitude of 80 meters above ground level for the KSC area goes from 12.3 to 14.5 mph. While this certainly exceeds the minimum wind speed requirements, this speed is on the lower end of average wind resource. This, however, does not point out that KSC is not a good candidate for wind power. The wind resource in the area merits a life cycle cost analysis, as it is a thorough possibility that wind generation could be life cycle cost effective.

Off-shore wind resources are, however, a lot better. According to NREL off-shore wind resource data, the average wind speed at an altitude of 50 meters above the sea surface is between 14.3 and 16.8 mph. While this difference between off-shore and on-shore wind resource may not seem very significant, the power in wind varies as a cubic function of the wind's speed. As such, off-shore wind will produce 50% more power, on average, than on-shore wind resources. This 50% difference comes from averaged on-shore speeds of 13.4 mph and averaged off-shore speeds of 15.6 mph.

###### *Avian Considerations*

A huge consideration in looking at implementing electrical wind turbines on KSC is the effect it would have on the avian wildlife. KSC is located on a vast expanse of wildlife refuge and many birds which reside

on KSC are endangered. Because wind turbines rotate at speeds high enough such that the spinning rotors can kill birds, avian considerations is the biggest concern to address in wind generation implementation.

Extensive literature survey shows varying data regarding the correlation between avian mortality and spinning wind turbines. Many different people have different reasons for writing. Wind companies and people of the green movement want to promote green energy, thus minimizing avian mortality as an issue, while bird lovers and other parties tend to aggrandize the numerous deaths. However, what can be said about wind turbines is that the rotation causes the turbines to move at average speeds of 45 mph around the axis of rotation.

Avian mortality is the reason why FPL's previous proposal for wind development at KSC was rejected. The proximity to the wildlife refuge raised a concern and as a result, the US Fish and Wildlife service stopped the project.

### III. Conclusion

Avian mortality is a huge item to consider when getting support for wind development on KSC. Whether or not the VAB kills more birds on average than a wind turbine (not necessarily true) is irrelevant to the case. The fact is that wind turbines do kill birds.

As a result, it is logical to come to the conclusion of developing offshore wind turbines when considering wind energy. Not only is the wind resource better, providing 50% more power, but also the risk of bird collision is less likely. Further research will need to be done regarding the effects of the turbine on fish and oceanic wildlife but based on this initial conclusion, it is preferable to look into off-shore wind.

### IV. Appendix

#### Calculations

##### Off-shore and On-shore wind differences

Average On-shore Wind = (Wind Minimum + Wind Maximum)/2

Average Off-shore Wind = (Wind Minimum + Wind Maximum) /2

Difference between Averages = (Average On-shore)^3/(Average Off-shore)^3

References: (Wind speeds)

[http://energybible.com/wind\\_energy/wind\\_speed.html](http://energybible.com/wind_energy/wind_speed.html)

<http://www.dailytech.com/Increasing+Cutin+Speed+of+Wind+Turbines+Results+in+Fewer+Bat+Fatalities/article20043.htm>

##### Rotation Speed

Average RPM = (RPM Maximum + RPM Minimum)/2

Average Diameter = (Diameter Maximum + Diameter Minimum)/2

Average Rotational Speed = Average RPM\*pi\*Average Diameter/60

References:

<http://www.bwea.com/ref/noise.html>

### Acknowledgments

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### References

The following pages are intended to provide examples of the different reference types, as used in the AIAA Style Guide. When using the Word version of this template to enter references, select the "references" style from the drop-down style menu to automatically format your references. If you are using a print or PDF version of this document, all references should be in 9-point font, with reference numbers inserted in superscript immediately before the corresponding reference. You are not required to indicate the type of reference; different types are shown here for illustrative purposes only.

## NASA USRP – Internship Final Report

<sup>1</sup>National Aeronautics and Space Administration. NPR 8553.1B NASA Environmental Management System. NODIS. [http://nodis3.gsfc.nasa.gov/npg\\_img/N\\_PR\\_8553\\_001B/N\\_PR\\_8553\\_001B.pdf](http://nodis3.gsfc.nasa.gov/npg_img/N_PR_8553_001B/N_PR_8553_001B.pdf) [cited August 4, 2011]

<sup>2</sup>Bush, George W. “Executive Order 13423: Strengthening Federal Environmental, Energy, and Transportation Management.” Federal Register. <http://edocket.access.gpo.gov/2007/pdf/07-374.pdf> [cited August 4, 2011]

<sup>3</sup>Obama, Barack. “Executive Order 13514: Federal Leadership in Environmental, Energy, and Economic Performance” Federal Register. <http://edocket.access.gpo.gov/2009/pdf/E9-24518.pdf> [cited August 4, 2011]